Understory Vegetation Recovery Monitoring in the Sub-Boreal Forest: The Shovel Lake Wildfire

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Prepared for SERNbc and Yun Ghunli Table

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Executive Summary

This vegetation monitoring project assesses the natural regeneration of culturally important berry and medicinal plant species across a range of habitats and fire severity conditions following the Shovel Lake fire of 2018. The fire affected 92,000 hectares of sub-boreal forest north of Endako and Fraser Lake, within the traditional territories of Nadleh Whut'en and Stellat'en First Nations.

Sub-boreal ecosystems are fire-adapted ecosystems that are generally resilient to historic wildfire. Given the compound impacts of mountain pine beetle, followed by salvage logging, followed by such a large and intense wildfire, monitoring of understory vegetation recovery is important in building our understanding of early succession vegetation response and in identifying potential restoration concerns, especially in a changing climate.

Vegetation monitoring transects were established on a range of sites in 2021 and remeasured in 2023, with a focus on recently logged mesic sites that burned at high fire severity. On high fire severity sites that had been salvage-logged prior to the fire, we observed huckleberry sprouting at about 0.5 mean cover in 2021 and 1% cover in 2023. Vegetation regeneration on mesic sites that burned at low or moderate severity is more advanced. Dry sites that burned to mineral soil are showing recovery of fire resilient shrubs and dry grasses. Wet forest and wetland understory vegetation was not as severely impacted by the fire and appears to be recovering well.

The most important factor in recovery of productive huckleberry patches is likely to be time; however, vegetation recovery warrants further monitoring due to the unprecedented fire and regional warming. Innovative silvicultural prescriptions could help restore berry productivity to meet cultural and wildlife habitat objectives. Reducing slash levels on future cutblocks could reduce future risk of high severity wildfire.

Acknowledgements

This project was guided by the Yun Ghunli Advisory Council, with representatives of two Carrier-Sekani First Nations, the BC Provincial Government, the Omineca Environmental Stewardship Initiative (ESI) and the Society for Ecosystem Restoration in Northern BC (SERNbc); and by direction flowing from the Shovel Lake Wildfire Ecosystem Restoration Plan.

Thank you to Nadleh Whut'en First Nation Lands Manager Bev Ketlo, Elder and Councilor Roy Nooski, Referrals Coordinators Rebecca DeLorey and Kirsten Chapman, and to Stellat'en First Nation Economic Development Officer Adam Patrick. Special thanks to Brittani Sterling, Serina Greene, Kirsten Chapman, Shane Heron and Victor Thomas for their contributions toward vegetation monitoring, forest enhancement, and the black huckleberry trial. Black huckleberry plugs were provided by Woodmere Nursery.

Funding was provided by SERNbc and the FEP.

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1. Introduction and Purpose

The Shovel Lake Wildfire of 2018 affected 92,000 hectares of sub-boreal forest north of Endako and Fraser Lake, within the traditional territories of Nadleh Whut'en and Stellat'en First Nations, and parts of Yekooche, Lake Babine and Cheslatta First Nations territories. Roughly two thirds of the disturbance occurred within the Stuart-Nechako resource district, of the Omineca region, and one third is within the Nadina district, of the Skeena-Stikine region, as shown in Figure 1. Implementation of the Shovel Lake Wildfire Ecosystem Restoration Plan (Price and Daust 2019) is a collaborative project guided by Yun Ghunli, an Advisory Council with representatives from 3 of 7 Carrier-Sekani First Nations, the BC Provincial Government, the Omineca Environmental Stewardship Initiative (ESI) and the Society for Ecosystem Restoration in Northern BC (SERNbc).

Sub-boreal ecosystems are fire-adapted ecosystems that are generally resilient to historic wildfire. Given the compound impacts of mountain pine beetle, followed by salvage logging, followed by such a large and intense wildfire, early post-fire reconnaissance and targeted monitoring of understory vegetation recovery is important in building our understanding of early successional vegetation trajectories and in identifying potential restoration concerns. Vegetation recovery is not linear, especially in a changing climate. The ERP made recommendations organized according to the restoration zones described in Figure 1. Within the special restoration zone, where cultural and ecological values have precedence, vegetation monitoring stratified by fire severity and ecosystem was recommended.

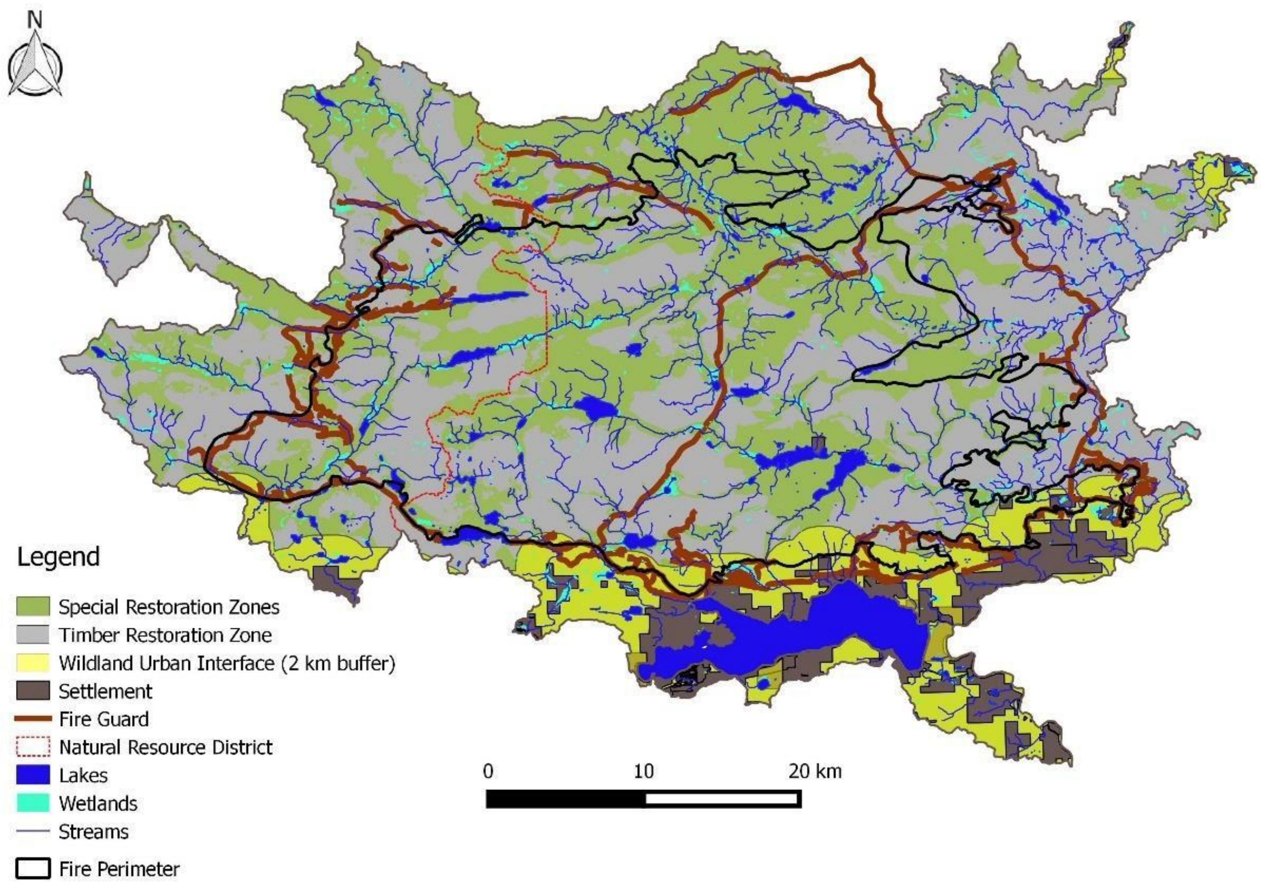

Figure 1. Shovel Lake wildfire boundary, natural resource district, and broad restoration zones.

Vegetation Monitoring Objectives

The objectives of the project were to assess the natural regeneration of understory vegetation across the wildfire, with a focus on sites that support culturally important berry and medicinal plant species across a range of site conditions. Vegetation monitoring was organized according to broad moisture gradients (dry, mesic, wet), Biogeoclimatic zones, fire severity, and age of stands prior to the fire. Monitoring focused in and around the multi-use cultural use areas at Ormond Lake, Sutherland River valley, and Shovel Lake, where multiple cultural values and services have high values, as described in Table 1.

Table 1. Special Restoration Zone – Multi-Use Cultural Use Areas.

Location	Cultural Values
Ormond Lake	Provides berries, medicinal plants, fishing (Ormand Creek between Ormand Lake and Fraser Lake) and moose habitat. A cultural camp near Ormand is well used. There is high archaeology potential in the region.
Sutherland River valley	High cultural values based on biodiversity, with meadow ecosystems and habitat for grizzly bears, wolves and moose. The Sutherland connects to the Babine watershed and has important connectivity values, ecologically and hydrologically.
Shovel Lake	Provides hunting, berry-picking, and other wildlife and fish habitat are all accessible together.

2. Background

Ecosystems of the Shovel Lake Wildfire

The Shovel Lake Wildfire burned through a landscape of sub-boreal ecosystems typically shaped by fire. Low-elevation ecosystems within the fire area include dry and moist Sub-Boreal Spruce biogeoclimatic subzones (primarily SBSmc2, with SBSdw3 in the southeast and SBSdk in the southwest and Sutherland Valley); Engelmann Spruce - Subalpine Fir subzones (primarily ESSFmv1 with some ESSFmc in the northwest) cover the mountains. Within biogeoclimatic subzones, variation in soil, topography and disturbance leads to diverse ecosystems. On south-facing slopes, dry open ecosystems with patches of shrubland or grassland provide spring wildlife habitat. These ecosystems typically burn frequently; as the climate continues to shift, they may revert to shrubland and grassland. In the gently rolling terrain, dotted with lakes and wetlands, rich and wet ecosystems, with important cultural and wildlife values, are scattered throughout (Price and Daust. 2019).

Natural Disturbance Regime

The sub-boreal forest is part of natural disturbance type (NDT) 3 which is characterized by frequent stand-initiating events. Historically, forests in the Sub-boreal Spruce zone burned once every 125 years on average. Fire size ranged from small spot fires to large stand-replacing fires covering tens of thousands of hectares. These wildfires often contained unburned patches, or fire “skips”, resulting in an overall landscape mosaic of even-aged regenerating forests ranging in size from few to thousands of hectares, surrounding patches of mature forest (Hall, 2010).

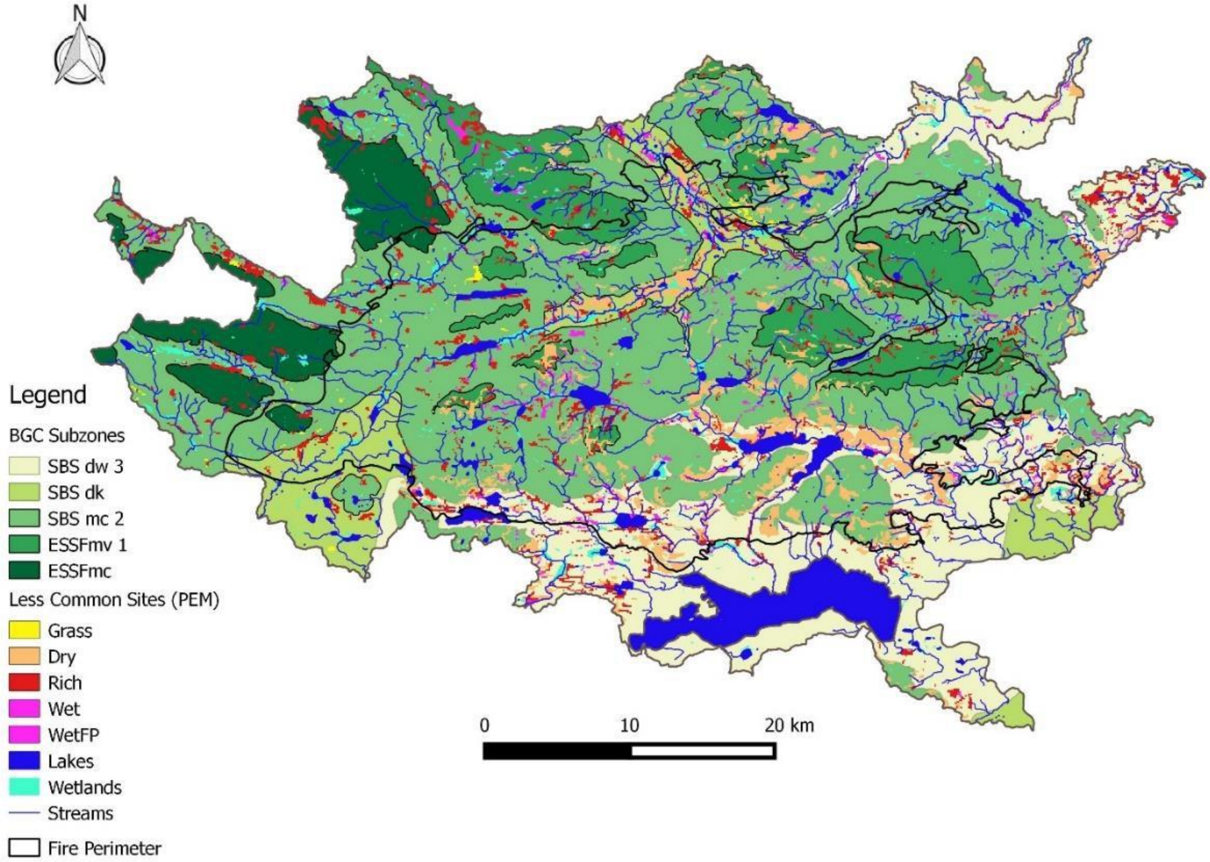

Figure 2. Ecosystems of the Shovel Lake Wildfire study area.

Biogeoclimatic subzones are shaded in green. Dark green shows ESSF subzones on mountains. Groups of special site series within subzones are shown as small patches of brighter colour. Dry ecosystems are primarily located on south-facing slopes; wet and rich sites are scattered throughout.

Climate Change Projections and Implications

Climate projections suggest that by the 2050's mean annual temperature could increase by 1.8°C to as much as 3.5°C in the Omineca Region, depending on greenhouse gas emission scenarios. A modest increase in precipitation is anticipated, however less winter precipitation will fall as snow, resulting in a reduced snowpack and resultant climate moisture deficits, particularly in summer. The number of growing degree days will increase and the number of frost-free days will increase. (PCIC 2020, Foord et al. 2015). One of the implications of regional warming is the expansion of the geographic extent and duration of drought events (Delong et al. 2019, Ministry of Forests. 2022).

In general, bioclimate modeling predicts that suitable habitat for black huckleberry could shrink at lower elevations and on drier sites, and expand at higher elevations, while the timing of flowering and fruiting could advance significantly (Prevey et al. 2020). The timing and intensity of precipitation and growing degree days have always influenced berry production - resulting in fluctuations in site-specific berry productivity from year to year. Deep snowpacks provide an insulating layer against heavy winter frosts and protects plants like black huckleberry from desiccation. The plants are susceptible to frost damage if snow is late to arrive or melts early. Late spring frost and summer drought may result in a failed or poor berry crop, as we have witnessed in 2023, while heavy spring rains may reduce the activity of pollinators such as bees.

Fire Severity

Fire severity mapping provides a basis for stratifying the study sites. Burn severity mapping is an imagery-derived dataset that represents post-wildfire vegetation condition. The burn severity classification is based on a Burned Area Reflectance Classification (BARC) analysis which results in polygons that are classified into 4 levels of impact: high, medium, low, and unburned (Mahood and Hearnden 2016). Burned sites are classified as low, moderate or high severity if tree crowns are predominantly green, brown or black, respectively (Hudak 2004).

Although Shovel Lake was a large intense wildfire, almost a quarter of the area was skipped and another quarter experienced low burn severity (Figure 3). Roughly one third of the area had high burn severity. The moderate severity areas are typically a mixture of moderate and low burn severity in these large stand-replacing fires.

Soil burn severity is a function of multiple site factors and does not always align with the BARC mapping. Vegetation and soil characteristics, amount and nature of ground fuels, weather at the time all influence soil burn severity (Parsons et al. 2010). Soil water repellency is emerging as a serious concern with respect to soil erosion and flood risk in the Southern Interior of BC where the typically sandy soils are more susceptible (Curran et al 2006).

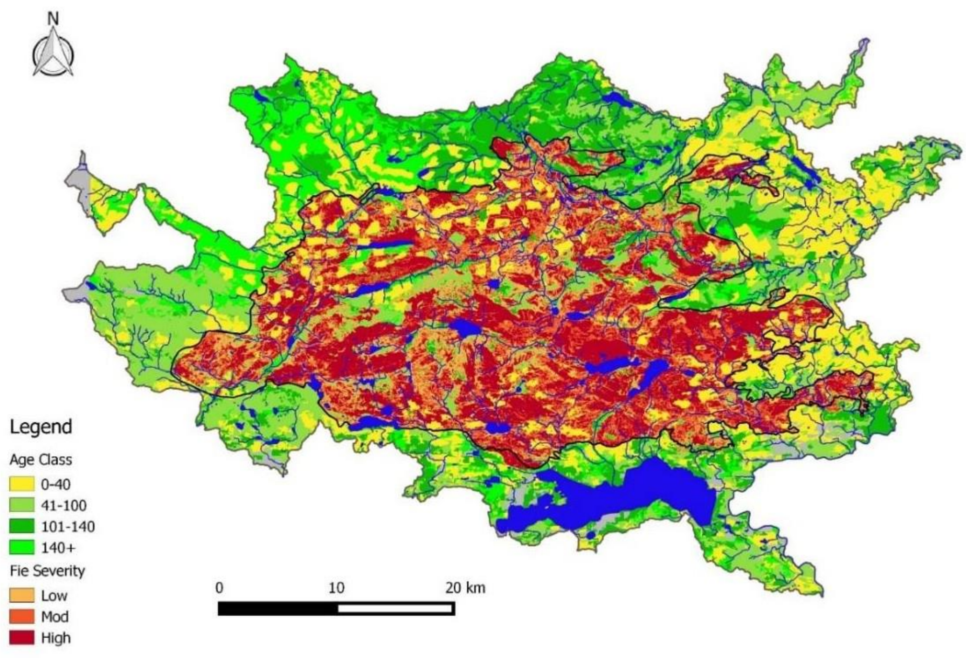

Figure 3. Burn severity overlaid over forest age class in the study area.

Wildfire Recovery and Ecosystem Resilience

In their report, *Burning Questions: the effects of fire on British Columbia's Ecosystems*, Evelyn Hamilton et al (2018) analyzed data from the "Swiss Fire", which burned 18,000 hectares of forest southwest of Houston in 1983. Vegetation monitoring plots were established within the Morice River Ecological

Reserve, which is located within the dry cool subzone of the Sub-boreal Spruce biogeoclimatic zone (SBSdk). The study found that:

- with low burn severities, berry plant cover was high initially, but peaked before ten years, then began to decline;
- with higher burn severities, berry plant recovery was slower but more sustained over a longer time period;
- although an increase in percent cover of berry producing species is generally positively correlated with fruit production, it should not be directly interpreted as an increase in the quantity or quality of edible berries; and,
- Lodgepole pine ecosystems are, in many respects, highly resilient to wildfire, but multiple burns occurring within a decade have the potential to undermine that resilience and to cause losses in valued resources such as huckleberries and blueberries that generally flourish after a single wildfire.

In a report on the effects of slashburning on restoration of edible berries and grizzly bear forage, Sybille Haeussler makes the point that "*an important reason why wildfires provide excellent wildlife habitat is that they can take 60 years or more to become fully stocked with trees. This long period without trees provides opportunities for relatively slow-recovering shrubs like huckleberries and blueberries to flourish. The well-known Burrage burn on the Stewart-Cassiar highway south of Dease Lake is an excellent example of one such un-reforested burn. Such long-standing berry patches could subsequently be rejuvenated with prescribed fire as First Nations in the northwest historically did (Gottesfeld 1994)*." (Haeussler 2015).

After a fire, plant species repopulate by two regeneration strategies: resprouting or seeding. Resprouters generate new shoots from dormant buds (roots or rhizomes) after stems have been scorched by fire. Postfire seeders regenerate by means of a fire-resistant seed bank, with seeds either stored in the soil or in the forest canopy (Pausas 2014). Plant species identified by the ERP for vegetation monitoring are all resprouters. The table in Appendix A provides a summary of fire ecology and post-fire regeneration strategies for each.

Plants that are able to resprout from root crowns or rhizomes after the passage of fire are said to be "endurers". Plants with deeper root systems will have greater protection from fire effects, and thus more resources from which to resprout. The depth of their roots depends on the individual plants species as well as in-situ factors such as thickness of the humus layer (Rowe 1983).

Early seral berry producing shrubs, such as raspberry, currant, and dwarf blueberry, tend to respond more quickly to fire and are often more abundant in the first 10 years post wildfire than on unburned sites. Late seral berry-producing shrubs, such as black huckleberry, velvet-leaved blueberry, and Devil's club, typically require a degree of shading and thus may take longer to recover unless a degree of residual overstory exists (Haeussler et al. 1999; Hamilton and Peterson 2007*).*

While it is important to distinguish between berry plant recovery and berry crop productivity, traditional knowledge and anecdotal evidence indicate that wild berry crops are most abundant following wildfire. Berry quantity and quality appears to have declined throughout western North America as fire suppression activities have increased (Hobby and Keefer 2010) and second-growth forests have matured (Haeussler 2015). Stellat'en and Nadleh have observed a decline in berry crops over the past several decades.

Culturally Important Plant Species by Moisture Gradient

The culturally important plant species occur in a range of ecosystems across the wildfire area. Table 2 provides a list of the commonly occurring species, and highlights the broad moisture gradients in which they are found, shaded according to prominence. Information is drawn from the biogeoclimatic field guides.

Table 2.Site series distribution of culturally important plant species.

	Moisture Gradient		
Plant Species	**Xeric**	**Mesic**	**Hygric**
Common juniper			
Soapberry			
Kinnikinnick			
Nodding onion			
Choke cherry			
Saskatoon			
Dwarf blueberry			
Arnica			
Prickly rose			
Wild raspberry			
Black huckleberry			
Highbush cranberry			
Devil's club			
Willows			
Labrador tea			

3. Methods

Study Design

SERNbc's monitoring protocol for prescribed burn effectiveness and associated standards for Tier I qualitative landscape assessments and Tier II site specific monitoring (Rooke et al. in progress 2015) provided guidance. Where vegetation regeneration appeared to be well underway, Tier I type qualitative monitoring was applied. Where regeneration concerns suggested further investigation, elements of Tier II site specific monitoring were applied.

To account for landscape and ecosystem complexity, the study area was stratified by burn severity, Biogeoclimatic zone, broad moisture gradient, and stand structural prior to the wildfire. For efficiency, specific combinations of strata were selected for. Burn severity categories were limited to null, low and high. (Sites interpreted as moderately burned according to the BARC classification are often a mix of low and no burn severity.) Monitoring was focused on the two dominant biogeoclimatic zones, SBSmc2 and SBSdw3, where road access was best. Concerns had been expressed over the impact of fire on recently salvaged MPB-killed stands, most of which burned at high severity according to the BARC mapping. To explore this, we selected for young 0–4-year-old cutblocks, where MPB and logging had been most recent; Age Class 2 stands, where understory vegetation had 21-40 years to regenerate following logging disturbance; as well as some Age Class 5 stands, where stand structure would interact differently with the fire. The monitoring transects therefor represent the following strata:

1. Burn severity: null, low, high;
2. Biogeoclimatic zone: SBSmc2, SBSdw3
3. Broad moisture gradient: xeric, circum-mesic, hygric.
4. Stand structural stage: 0-4 yrs., Age Class 2, and Age Class 5

For reference condition, the regional site interpretation and classification field guides provide site unit descriptions organized according to moisture and nutrient gradients (Banner et al 1993, Beaudry et al, 1999). Note that these site descriptions reflect plant distribution and potential at late successional stage. Monitoring transects on unburned sites also serve as a reference.

Site-Specific Monitoring

Monitoring transects were place in null, low and high severity burn areas as summarized in Table 5. Note that a few transects were also placed on xeric sites near Oona Lake. The monitoring locations are well distributed geographically across the fire area. Transects were established in 2021 and resurveyed in 2023. Methods of Field Site Selection and Field Sampling Protocol are provided in Appendix B.

Table 3. Transects by ecosystem type and burn severity.

Burn severity	Null	Low	High
Ecosystem moisture			
SBSdw3 dry			2
SBSdw3 mesic	1	3	
SBSmc2 mesic	2	6	8

4. Results

Reconnaissance

Early in the project we toured the wildfire with Elder and Councilor Roy Nooski, and Nadleh Lands Manager, Bev Ketlo. Roy summarized his observations as follows: "*A loo yen yan be na de lya*" or, *Mother nature healing itself by wildfire*. The mesic forests that had burned at low severity along the Ormand and Oona Lake Road were in flower, including species that are often only seen after fire when the seed bank is exposed: pink corydalis, golden corydalis, Bicknell's geranium, Franklyn's phacelia, as illustrated in Figure 4a. The dry forest sites with sandy-gravelly soils adjacent Oona Lake had burned at high severity, leaving the mineral soil exposed, but fire-resilient shrubs like soopolallie, Saskatoon, dwarf blueberry and kinnikinnick were sprouting back up from burned root crowns as shown in Figure 4b. Transects were placed at Oona Lake to describe vegetation cover.

The Nadleh berry patch on the lower Sutherland FSR had a mix of low, moderate and no burn. Black huckleberry shrubs showed signs of scorch as well as fresh growth as shown in Figure 4c. By contrast, subsequent surveys up Angly, Sutherland, Bromberger, Hanson and Hannay Forest Service Roads revealed that recent Mountain-Pine Beetle-salvaged cutblocks generally burned at high severity. The blocks were burned to mineral soil on these predominantly mesic sites. The shrub and herb layers were consumed by the fire. Black huckleberry shoots were observed sprouting from underground rhizomes. However, the shoots were often less than a few centimeters in height and extremely patchy in distribution as shown in Figure 4d, and warranted further investigation.

Figure 4. Reconnaissance photos. (A) Roy Nooski observing understory bloom in low severity burn near Ormand Lake. (B) Soopolallie and dry sedge regeneration on dry high fire severity burn at Oona Lake. (C) Recovery of Black huckleberry and other species in young 12-year-old stand on mesic low severity burn at the Nadleh berry patch. (D) Black huckleberry sprouting on mesic high severity burn of recently BPB-salvaged cut block above Angly Lake.

Wetland Sites

Wetland sites were surveyed at Stern and Owl Lakes, and along Upper Angly, Upper Sutherland, and Tatsunai Creeks. According to the BARC mapping burn severity on these sites ranged from high to low. All sites showed signs of only partially impacted humus layers and abundant vegetation regeneration. Vegetation plots were placed at Stern Lake, Tatsunai Creek and the site near Echo Lake. The photos in Figure 5 show the status of vegetation recovery on several of these sites in 2021.

Figure 5. Wetland monitoring. (A) P127L Regenerating Labrador tea in low severity burn of Black spruce bog north of Stern Lake. (B) V126M Willow regeneration in low severity burn of wetland at Stern Lake. (C) P65H Riparian zone recovery in high severity burn along Tatsunai Creek. (D) P128LM Wetland recovery in low severity burn near Echo Lake.

Mesic Sites

Monitoring transects were initiated on mesic sites to help assess differences in vegetation recovery on recently logged sites compared to older stands. While the data is “noisy” in that vegetation distribution is inherently patchy, there are some patterns that emerge as illustrated in Figure 6. Regardless of structural stage, sites that burned at high intensity had lower mean cover of black huckleberry, as shown in the right two box and whisker graphs; sites that burned at low intensity had greater mean cover 2 years post-fire and had significant gains in cover by 2023, as shown in the center two box and whisker graphs. As a reference, unburned sites had good cover of black huckleberry in 2021 and modest gains by 2023, as shown in the left two box and whisker graphs.

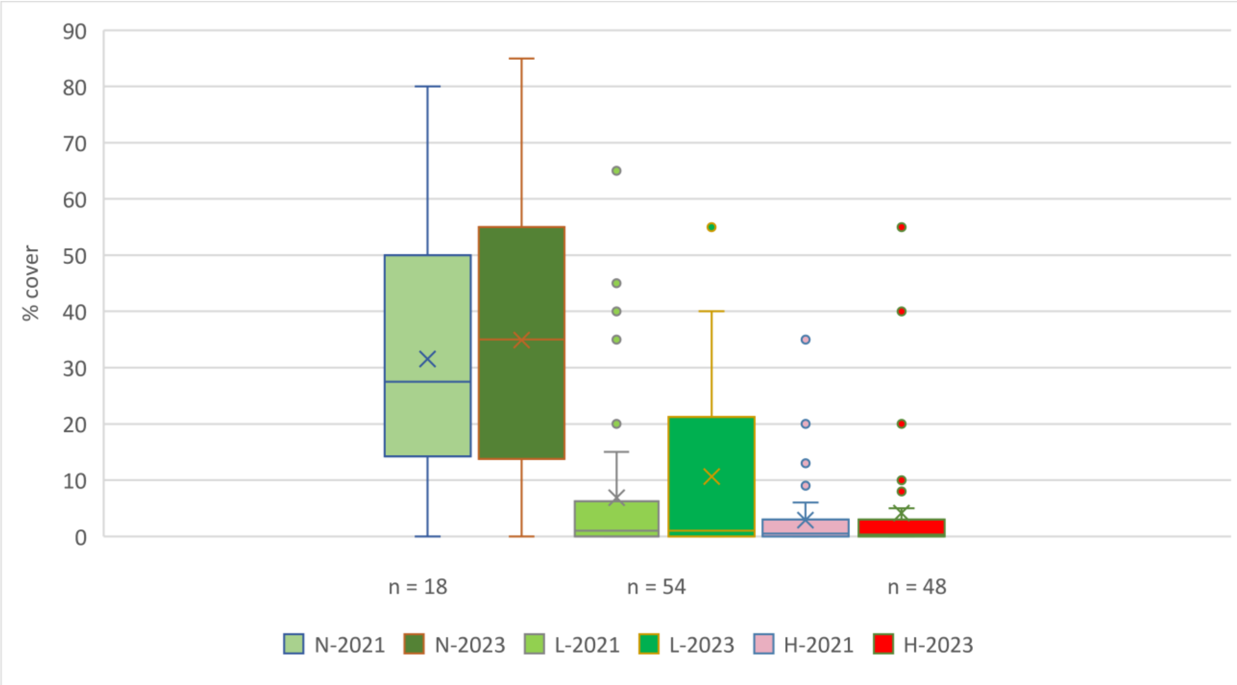

Figure 6. Percent cover black huckleberry across null, low and high burn severity transects, 2021 and 2023.

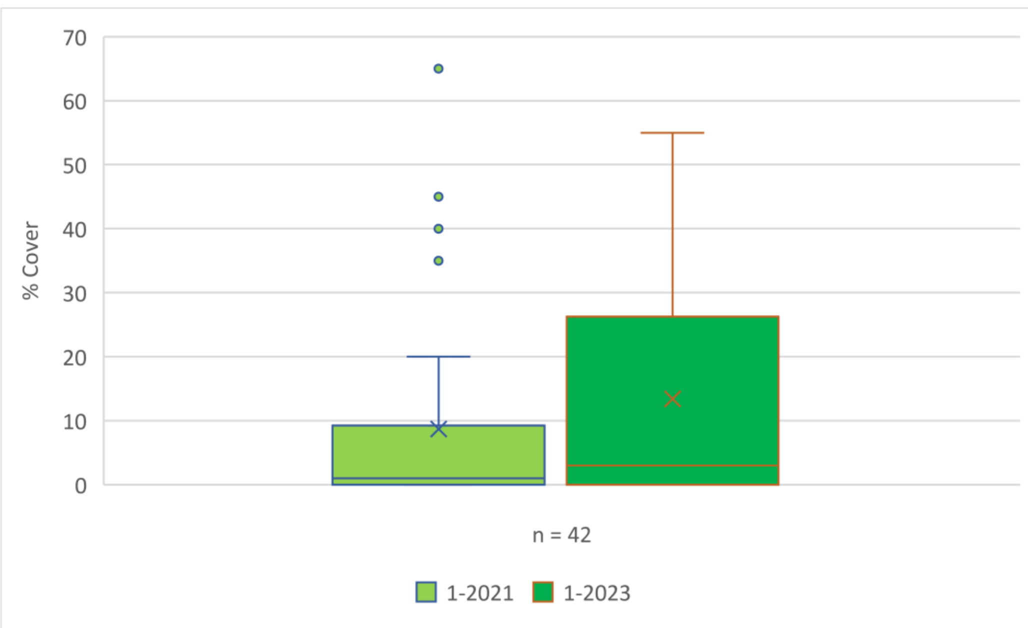

Figure 7. Percent cover black huckleberry by age class on low burn severity transects, 2021 and 2023.

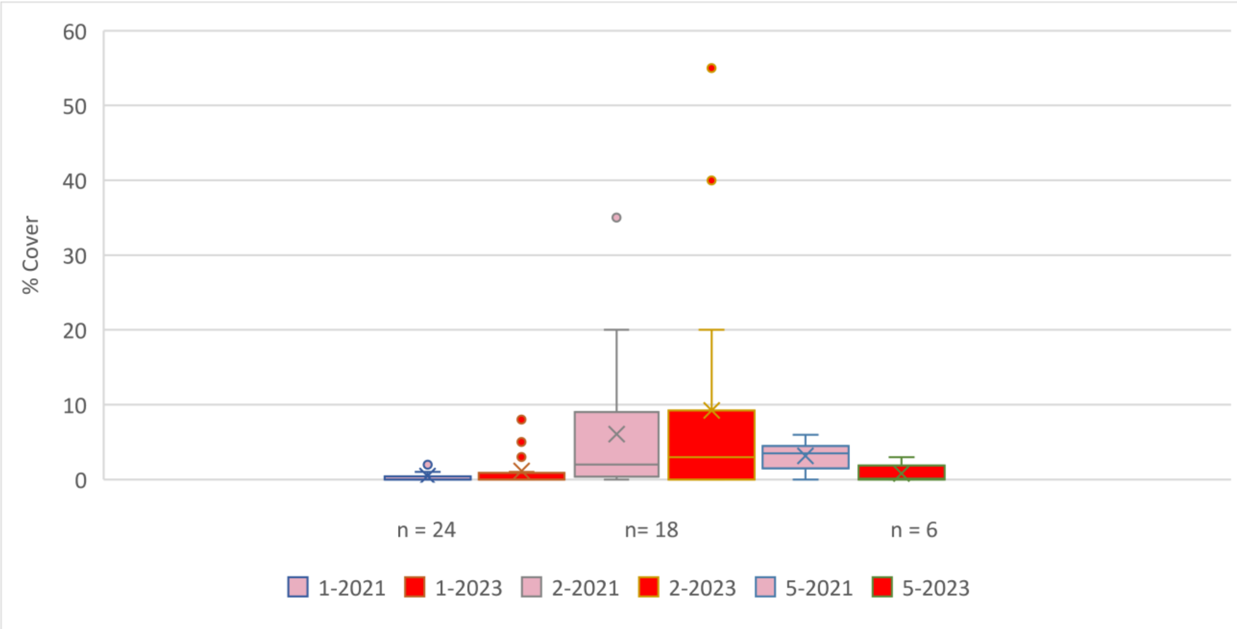

Figure 8. Percent cover black huckleberry by age class on high burn severity transects.

In young stands that burned at low severity, black huckleberry patches are regenerating well, as illustrated in Figure 7. On these sites, mean cover of black huckleberry increased from about 9% in 2021 to 14% in 2023, representing a 60% increase in overall cover. By contrast, in young stands that burned at high severity, black huckleberry patches had a mean cover of less than 0.5% in 2021 and just over 1% mean cover in 2023, as illustrated in Figure 8. While this represents a 50% increase in black huckleberry cover over 2 years, 1% cover is still very low. Age Class 2 stands that burned at high severity had a mean cover of around 6% in 2021 which increased to 9% by 2023; while the Age Class 5 stand that burned at high severity had a mean cover of 3% in 2021 and dropped to just under 1% in 2023. It is important to note that 2023 weather patterns may be a confounding factor in that the early season heat followed by frost in early June, as well as the summer drought has likely resulted in reduced overall vegetation growth. Black huckleberry appeared to be particularly susceptible to leaf scorch and desiccation, as illustrated in Figure 9, below. Figure 10 provides images from some of the monitoring transects that burned at null, low and high severity.

Figure 9. Black huckleberry showing signs of heat scorch, upper Sutherland valley, 2023.

Figure 10. Monitoring transects on mesic Hybrid White spruce – Lodgepole Pine – Huckleberry null, low, and high burn severity sites. (A) Young unburned stand, Tatin Lake. (B) Young stand that burned at high severity, above Echo Lake. (C) Young stand that burned at low severity south of Hanson Lake. (D) Age Class 5 stand that burned at high severity, above Echo Lake. (E) 13-year-old stand that burned at low severity, Sutherland berry patch. (F) Age class 2 stand that burned at high severity, south of Echo Lake.

Figures 11 through 13 provide a bit of a visual summary of some of the differences in vegetation response on young and Age Class 2 sites, that burned at low and high severity. Green alder was observed sprouting up from burned root crowns throughout the fire, but at lower cover on high severity sites than on low severity sites. Alder is a nitrogen-fixing species that plays a particularly important role after wildfire disturbance, when a substantial amount of the existing nitrogen pool has been volatized (Swanson et al. 2010). Birch-leaved spirea appears to have consistent cover on high and low severity sites; it is reported to be highly resilient to wildfire and will flower in the first year following fire. Dry sedges, such as Ross's sedge and bronze sedge sprouted readily from the seed bank in exposed mineral soil, helping to stabilize soil and provide a source of organic matter.

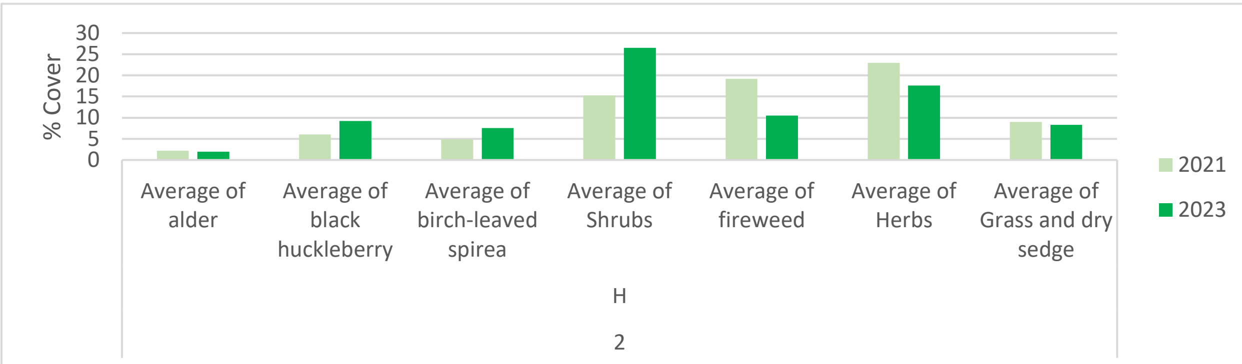

Figure 11. Percent cover on mesic age class 2 high burn severity sites, 2021 and 2023.

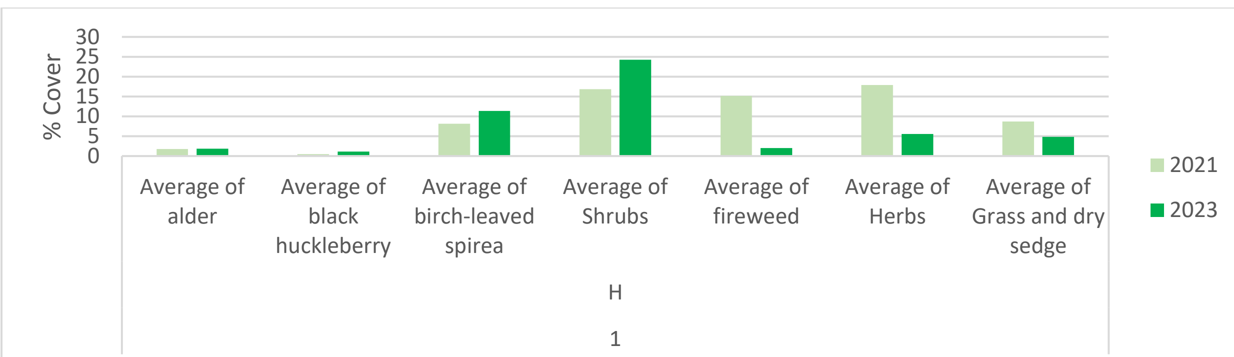

Figure 12. Percent cover on mesic young (0-4 yr.) high burn severity sites, 2021 and 2023.

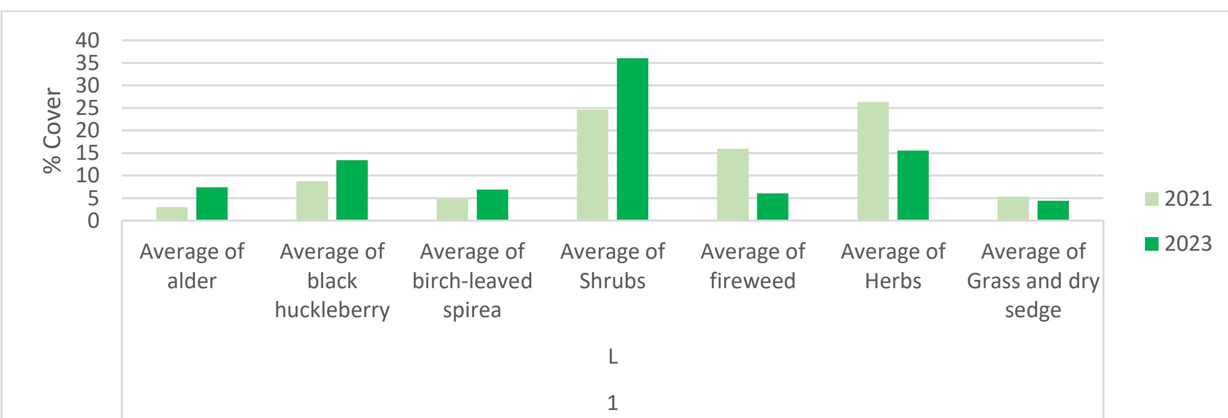

Figure 13. Percent cover on mesic young (0-4 yr.) low burn severity sites, 2021 and 2023.

Introduced species, such as narrow-leaved hawkweed, white hawkweed, orange hawkweed and common dandelion were observed at very low cover on the transects, generally less than 0.1% cover overall. While presence of introduced species appears to be more common along roadside ditch lines, they do not appear to be spreading to regenerating forest areas. Low incidence of introduced species may be associated with lack of cattle grazing. Range tenures within the study area are limited to 367 hectares in the extreme southwest corner and 732 hectares in the southwest corner.

Dry Sites

The dry Pine – Feathermoss - Lichen -sites adjacent to Oona Lake are susceptible to burning at high fire severity and they did, burning to mineral soil in most areas. These are dry, nutrient-poor, glaciofluvial sites that typically have an open canopy of lodgepole pine, with low herb cover dominated by kinnikinnick, and dwarf blueberry; along with rough-leaved ricegrass and reindeer lichen in the openings. All of these species are present on site with a low patchy cover. A summary of dominant vegetation cover measured in 2021 and 2023 is provided in Figure 14. Cover of soopolallie (buffalo berry), kinnikinnick, dwarf blueberry, and rough-leaved and short-awned rice grasses increased significantly from 2021 to 2023, while prickly rose and Saskatoon decreased somewhat. Cover of bunchberry decreased from just over 1% cover to about 0.1% cover.

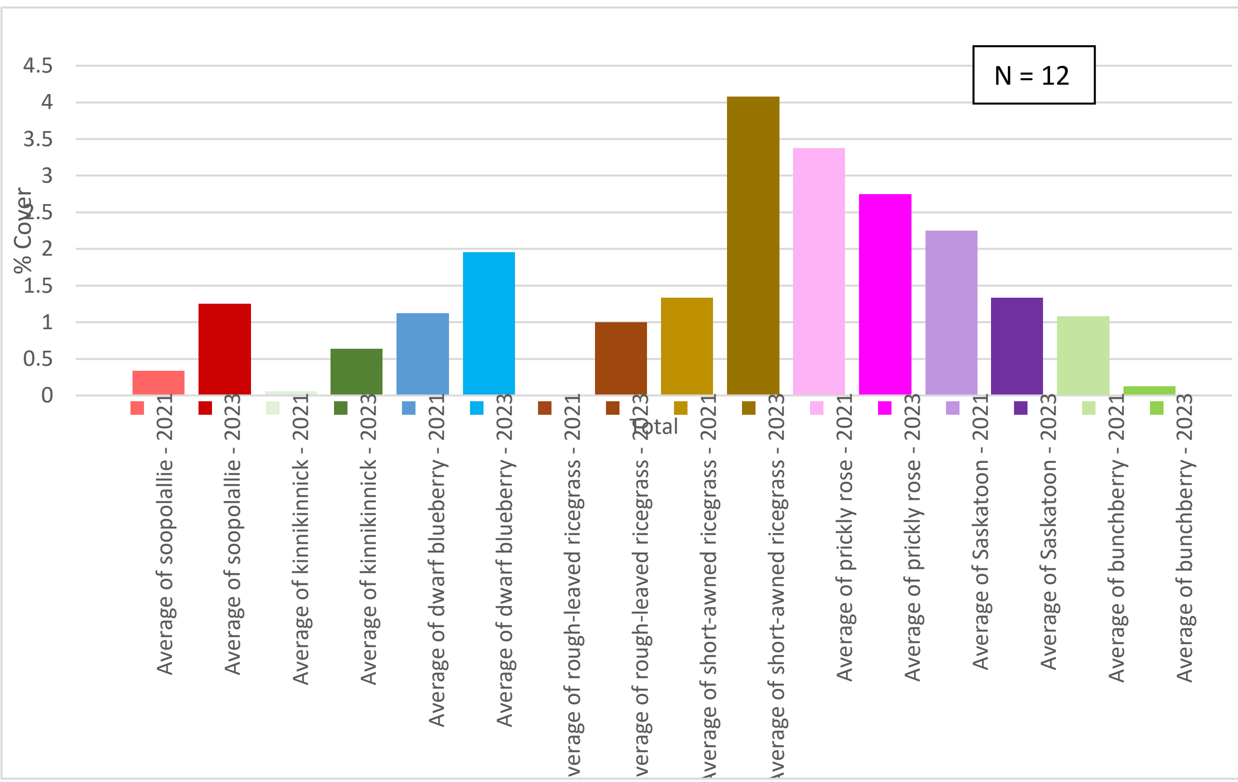

Figure 14. Percent cover of select species on dry age class 5 high burn severity sites, 2021 and 2023.

Figure 15. Dry Lodgepole Pine – Lichen site that burned at high severity, Ormond Lake. (A)Transect view facing south toward Ormond Lake. (B) Soopolallie, dwarf blueberry, twinflower and ricegrass regeneration.

1. Discussion

Ecosystem restoration is the process of assisting with the recovery of an ecosystem that has been degraded, damaged, or destroyed by re-establishing it ecological processes and structural characteristics (SERNbc).

Historically, natural and Indigenous fire resulted in a complex landscape mosaic of regenerating forests ranging in size, age, and burn intensity, and thus berry patches were maintained across the landscape over time. Prior to the fire, Nadleh Whut'en and Stellat'en First Nations had observed a decline in berry productivity. In effect, the 2018 fire has created an opportunity for restoring productive berry patches across the landscape.

The study area is a mix of null, low, mixed, and high severity wildfire disturbance which has effectively reset forest succession to early stages in some areas and left behind a diverse patchwork of stands of varying levels of disturbance and structural complexity across much of the landscape. Such biological legacies and residual structure are key to ecosystem resilience and continuity (Burton. 2010). Yet novel climate and associated weather extremes could undermine this resilience.

The anticipated successional trajectory pattern in which early successional communities are dominated by annual herbaceous species for the first few years after disturbance and quickly replaced by perennial herbs and shrubs (Swanson et al. 2010) is demonstrated by the monitoring. On mesic sites, the spectacular wave of fireweed that was apparent in 2021, was already diminished in extent by 2023, and slowly being replaced by a host of shrubs including birch-leaved spirea, alder, and varying amount of black huckleberry, dwarf blueberry, and twinflower. On dry sites, the diverse display of annual herbs such as pink corydalis, golden corydalis, and Bicknell's geranium captured in our monitoring in 2021, was being replaced by kinnikinnick, birch-leaved spirea, dwarf blueberry and soopolallie by 2023.

Sites which experienced the cumulative disturbance effects of mountain pine beetle kill, followed by salvage logging, closely followed by wildfire appear to have the lowest recovery of understory vegetation. Salvage logging left high levels of slash (fine fuels) on these sites, which although legal, contributed to the high fire severity observed on these sites (FPB. 2019). Age Class 2 stands that burned at high severity have higher recovery of black huckleberry, which might be attributed to a combination of relatively low levels of logging slash on site and the fact that the understory had over 20 years to recover from logging disturbance.

In his discussion paper on ecological sustainability and resilience related to the mountain pine beetle epidemic, Phil Burton suggests that we need to distinguish between ecological disturbance and ecological degradation. Our forests are well-adapted to disturbance. He points out that even severely burned forest with delayed tree regeneration contribute important habitat diversity to the landscape.

Shrubs will continue to grow even after canopy closure, but berry production requires sunlight transmission. Research indicates that black huckleberry productivity is maximized at about 60% to 70% light transmission. Sites with high conifer regeneration and/or tree-planting, have about a 10-15-year time window for huckleberry plants to regenerate and maximize berry production before light levels drop off due to canopy closure, causing a decline in berry production. Sites with little or no natural conifer regeneration could have a significantly longer time frame (Lilles. 2016).

The most important factor in recovery of culturally important species like black huckleberry is likely to be time. Further monitoring in high severity burn areas is warranted due to the unprecedented fire and the changing climate. Managing the landscape for diverse seral stages including early-successional forest ecosystems would help restore habitat diversity to the landscape (Swanson et al 2010). Introduction of innovative silvicultural prescriptions could help extend berry patch productivity over a longer time-frame to meet cultural and wildlife habitat objectives.

Cluster planting or planting with gaps, as championed by Ruth Loyd, would help maintain open patches of understory vegetation for an extended period of time during stand development and could be applied across the landscape. Yun Ghunli is working with licensees on initiating cluster-planting trials. Broader application of the '1 hectare not satisfactorily restocked allowance' would also allow room for other values. And, specific cultural sites, such as the Nadleh berry patch on the Sutherland FSR, could be managed as berry patches or medicinal plant collection areas. A stand thinning trial was initiated at this berry patch in 2021. The stand management prescription was for spacing of lodgepole pine and partial removal of Sitka alder, to enhance the 12-year-old pine and spruce plantation for black huckleberry. In fall 2023, a black huckleberry planting trial was initiated on the portion of the berry patch that intersects with the Coastal Gas Link Right-of-way. Further information about these trials is provided in Appendix D and E. Climate and drought projections indicate that future fires in the Omineca and Skeena Regions could be larger and more devastating (Ministry of Forests. 2022). Levels of logging slash should be managed to reduce the likelihood of severe wildfire on cutblocks.

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Appendix A. Culturally sensitive plant species and fire effects [1]

Species	**Fire Ecology**	**Post-fire Regeneration Strategy**
Black huckleberry (*Vaccineum membranaceum)*	Foliage is of low flammability, allowing for survival after low severity fires, with top-kill resulting from higher severity fires.	Top-killed plants sprout from rhizomes. Rhizomatous shrub, rhizome in soil (Miller 1977). A fire resilient species. Rhizomatous and thus it can form spreading clones. New plants are formed when underground rhizomes become separated from the parent plant through decay or disturbance (Minore et al. 1979). Huckleberry rhizomes are typically found within 8-30 cm of the soil surface, but may occur up to 1 m deep (Minore 1975).
Dwarf blueberry (*Vaccinium caespitosum)*	Underground portions can survive most light to moderate fires. However, rhizomes are relatively shallow and may be killed by hot duff-reducing fires (Hungerford 1986).	Shallow rhizomes may enable dwarf blueberry to sprout and quickly reoccupy a site after most light to moderate fires (Hungerford 1986). After severe treatments in which rhizomes are eliminated, reestablishment most likely proceeds slowly through seedling establishment or clonal expansion at the burn's periphery.
Velvet-leaved blueberry (*Vaccinium myrtilloides*)	Portions of stem bases occasionally survive light fires. Underground regenerative structures generally survive all but extremely hot fires. Rhizomes, which occur at depths of 0.24 to 1.2 inches (6-30 mm), can survive fires in which soil surface temperatures reach 820 degrees F (438 degrees C) (Uggla 1959).	Commonly sprouts from underground rhizomes or, when damage is less severe, from axillary buds located at the stem base (Uggla 1959). Clonal vigor is often enhanced by fire. Old, large, decadent clones are often broken up by fire (Noste et al. 1987). Surviving portions serve as isolated centers of regeneration which give rise to the development of vigorous daughter clones.

[1] USDA Fire Effects Information System. Available at https://www.fs.fed.us/database/feis

Birch-leaved spirea (*Spiraea betulifolia*)	White spirea is highly resistant to fire-kill. It sprouts from surviving root crowns, and from rhizomes positioned 2 to 5 inches (5-13 cm) below the soil surface (Crane et al. 1986).	White spirea demonstrates high survival capabilities following large wildfires. It is a rhizomatous shrub that not only survives burning, but can often flower the year immediately following the burn surface (Crane et al. 1986).
Common juniper *(Juniperus communis)*	Susceptible to fire. Foliage is resinous and very flammable (Diotte et al. 1989). The degree of damage received increases with progressively greater fire severity. In eastern Canada, older common juniper often survives fires of low severity.	Often survives on sites made up of exposed bedrock or where protected by lakes and island complexes. Common juniper also reestablishes after fire through off-site seed dispersed by birds or mammals.
Green alder (*Alnus viridis subsp crispa*)	Considered a survivor species because it sprouts from underground parts following fire, and wind-dispersed seeds will colonize bare mineral soil (Rowe, J.S. 1983)	Geen alder is abundant in areas with a history of frequent fires. This nitrogen-fixing alder may be favored over other invading species by severe fires that remove the surface organic matter. Alder invasion and persistence are favored by fire, but total recovery is slow (Pojar et al. 1984).
Soapberry (*Shepherdia canadensis)*	Sprouting from surviving root crowns and establishment from seed transported from off-site allow russet buffaloberry to survive fire (Noste et al. 1987).	Tall shrub, adventitious-bud root crown. Sprouts from surviving root crowns and establishment from seed transported from off-site fire (Noste et al. 1987).
Saskatoon berry (*Amelanchier alnifolia)*	Fire resistant. Deeply buried rhizomes enable Saskatoon to sprout after even the most intense wildfire. Recurrent low intensity ground fires may maintain density and vigor (Noble. 1985)	Sprouted mostly from upper portions of the root crown. When the root crown was killed by fire, Saskatoon sprouted from rhizomes further beneath the soil surface. Seed production may resume soon after fire (Bradley, Anne Foster. 1984).
Kinnikinnick (*Arctostaphylos uva-ursi)*	Kinnikinnick is a sprouting species that is best suited to short fire cycles with low fuel buildup and low fire intensities (La Roi et al. 1980).	Latent buds on the horizontal stems and dormant buds on the stem base or root crown allow sprouting of surviving plants or rooted stems. In northern Saskatchewan, it is a strong sprouter from golfball-sized lignotubers located in mineral soil (Rowe 1983). Shade intolerant.
Choke cherry (*Prunus virginiana)*	Well adapted to disturbance by fire.	Fire often kills aboveground chokecherry stems and foliage, but it quickly sprouts from surviving root crowns and rhizomes, either the same year following a spring burn, or by the next growing season (Volland et al. 1981).
Prickly rose (*Rosa acicularis)*	Moderately fire resistant. Can sprout from the base of fire-killed aerial stems or from rhizomes (Parminter 1983, 1984).	Because rhizomes are located in mineral soil, prickly rose is well-adapted for sprouting after fire [10]. Roses germinate from on-site and off-site seeds as well. Prickly rose seeds are

		fire resistant, and germination may be stimulated by fire (Parminter 1983, 1984).
Wild raspberry (*Rubus idaeus)*	The life cycle is integrally associated with disturbances such as fire. In many areas of vigorous fire suppression, both plant vigor and abundance have decreased. Red raspberry typically flourishes, completes its life cycle and declines within the early years after disturbance. As shade levels increase in the postfire community and soil nitrate levels drop (generally during the first 5 years after fire), red raspberry shifts resource allocation from vegetative growth to seed production (Whitney 1982).	American red raspberry is well adapted to reoccupy a site quickly after fire. This common "fire follower" is favored by increased amounts of nitrates present on burned sites and generally exhibits rapid and vigorous postfire growth through sprouting and/or seedling establishment (Watson et al. 1980).
Red osier dogwood (*Cornus stolonifera)*	Most fires only top-kill red osier dogwood shrubs (Archibold 1979). Mortality is likely restricted to severely burned sites where duff and litter are consumed and upper soil layers experience extended heating.	Tall shrub, adventitious buds and/or a sprouting root crown. Small shrub, adventitious buds and/or a sprouting root crown. Secondary colonizer (on- or off-site seed sources).
Devil's club (*Oplopanax horridus)*	Wildfire is uncommon in forest-devil's club ecosystems[28]. Typically, the moist ravines and streamside areas serve as a fire break to low- and moderate-severity ground fires.	Susceptible to fire although thought to resprout from the root crown and/or rhizomes. It may re-establish after wildfires from animal-dispersed seeds after the canopy has closed enough to shade this light-sensitive species.
Lady fern (*Athyrium felix-femina)*	Top-killed by fire. Fire decreases cover and frequency on drier sites, but sprouting is likely on subhygric sites (Hamilton 2006).	Lady fern sprouts from surviving rhizomes following fire.
Cow parsnip (*Heracleum lanatum)*	May benefit from both canopy removal and increased water availability after tree cover is removed by fire. Cow parsnip had greater percent cover following both wildfire and clearcutting without scarification (some stands broadcast burned) than after clearcutting with scarification (Zager et al. 1980).	Ground residual colonizer (on-site, initial community).
Highbush cranberry (*Viburnum edule)*	sprouts within weeks following fire and often becomes one of the dominant postfire shrubs (Haeussler, Coates 1986). Low-severity fires stimulate germination of seeds stored in the soil (Hamilton, et al. 1988). Abundance of the plant may be initially reduced after fire, but an	survivor species; on-site surviving root crown or caudex survivor species; on-site surviving rhizomes ground-stored residual colonizer; fire-activated seed on-site in soil off-site colonizer; seed carried by animals or water; postfire yr 1&2

	increase over pre-fire density may take place within the next 10 years.	secondary colonizer; off-site seed carried to site after year 2.
Grayleaf willow (*Salix glauca)*	Grayleaf willow is a fire-adapted species. Most plants sprout from the root crown following top-kill by fire. Viereck and Chandelmeier [36] reported that even old, decadent willows sprouted prolifically immediately after fire. The sprouting ability of willows is apparently more vigorous and prolific than that of birches or alders [36]. Grayleaf willow's abundant, wind-dispersed seeds are important in colonizing burned areas. Seeds are dispersed in the fall, overwinter under snow, and germinate in the spring. Thus, seedling establishment cannot begin until postfire year 2.	Survivor species; on-site surviving root crown or caudex off-site colonizer; seed carried by wind; postfire years 1 and 2 off-site colonizer; seed carried by animals or water; postfire yr 1&2.
Labrador tea (*Ledum groenlandicum)*	Regeneration following fire is typically rapid. When burned only "lightly," such that some above ground stem material survives, bog Labrador tea may sprout from stems. When completely top-killed, sprouting occurs from the root crown or rhizomes. Rhizomes are typically 5.9 to 20 inches (15-50 cm) deep and survive shallow burning. Provided a seed source is present, Labrador tea's high seed production and easily wind-dispersed seed suggests a high likelihood of burned site colonization.	When burned only "lightly," Labrador tea may sprout from surviving stems. When completely top-killed, sprouting occurs from the root crown or rhizomes. Rhizomes are typically 5.9 to 20 inches (15-50 cm) deep and survive shallow burning (Parminter 1984). The deepest underground reproductive tissue, tissue that is capable of regenerating if the upper plant is destroyed, averaged 18 inches (45 cm) in 25 Labrador tea plants excavated from treed and treeless bogs in New Brunswick's Acadian forest. Labrador tea survival of even severe fires is likely given this deep underground vegetative reproduction potential (Flinn 1980).
Willow species (*Salix spp.)*	Willows are greatly favored by fire in most habitats (Haeussler et al. 1990). As a survivor and off-site colonizer, Scouler's willow is abundant following fire and has a moderate regeneration period. It is adapted to fire by rapidly resprouting from the root crown, and establishes from seed on severely burned sites. Wind dispersed seeds facilitate rapid recolonization of burned areas. In a north-west Montana study Scouler's	Scouler's willow layer groups are distinct shrub layers that occur in various habitat types and are created by stand replacing fires. Severe wildfires expose patches of bare mineral soil, encouraging the development of Scouler's willow shrub layers. These layer groups may also develop in response to mechanical scarification in clear-cuts and broadcast burns, especially where exposed soil was mounded to trap water behind the mounds, creating well-watered seedbeds of mineral soil (Forsythe 1975).

	willow was found on 80% of burned sites with no previous Scouler's willow presence. Stand replacing fires favor regeneration of Scouler's willow, and good response from Scouler's willow seedlings can be expected on sites where fire damage is thorough enough to expose mineral soil. However, it is rarely present on sites where more than 50% of the pre-fire overstory remains (Forsythe 1975).	

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Appendix B: Field Methods and Supplies

Field Site Selection

Pre-field GIS stratification:

a. Identify contiguous areas of low-, moderate-, and high-severity fire using thematic maps of dNBR (differenced Normalized Burn Ratio) -derived fire severity;
b. Identify areas of circum-mesic, dry, and wet ecosystem types using terrestrial ecosystem mapping overlay;
c. Identify structural stage using Forest Cover layer;
d. Identify potential monitoring sites within the Special Management Zones that are within 200 meters of road access for efficiency and movement of the field crew; and,
e. Select random waypoint options within each potential transect location.

Field Sampling Protocol

In order to measure patches of vegetation with low cover values, visual cover estimates were made using a 1 x 1 m Daubenmire quadrat at 5-meter intervals along a 30-meter transect (Rochefort et al. 2013, Thacker et al. 2015, in Leverkus et al. 2018).

1. Once on site, confirm sites series and describe site and soil attributes according to Field Manual for Describing Terrestrial Ecosystems (Ministry of Forests, 2010).
2. Mark the transect commencement with 30 cm rebar. Place metal label, mark with flagging tape, and record transect location and identification on iPad.
3. On a random azimuth, establish a 30 m linear transect. Record bearing. Mark the end with 30 cm rebar, pigtail and metal label. Stake the end and leave the measuring tape in place. At 5 m intervals place a 1 x 1 m quadrat, alternating from right-hand side of the measuring tape to the left at each 5 m interval (Figure X). the following edge of the quadrat should align with the 5 m increment.
4. Within each quadrat, identify all plant species and percent cover. Record in Excel spreadsheet on iPad.
5. Within each quadrat, estimate cover of surface substrates: forest floor/leaf litter, coarse woody material, exposed mineral soil, rock; (sum = 100%).

Field Supplies

Plot Set-Up
Field protocols on waterproof paper and in plastic bags
iPAD, compass, clinometer, extra batteries, stake flags, flagging tape
Rebar, pig tails, metal tags
50 m tapes
Quadrat Plots 1 x 1 m plot frames made out of plastic plumbing pipe, marked at 10 cm increments
Safety Equipment (Field)
First Aid kit
SPOT, battery charger, extra battery, instructions
Bear spray in holsters
Hand-held radios, battery chargers and batteries, and radio frequencies
Safety Equipment (Truck)
Tool box, road atlas for northern BC
Emergency contact information, safety protocols

Appendix C. Species cover summaries, 2021 and 2023

Mean vegetation covers by Age Class for transects on mesic, unburned sites, 2021 and 2023.

Location	Tatin Lake FSR			S of Echo Lake			Hanson Lake FSR		
Site	T117_1N			T55_2N			T122_ 5N		
BEC	SBSdw3/ 01			SBSmc2/ 01			SBSmc2/ 01		
Site and soil	Moderately-well drained, loamy soils on morainal blankets								
Age Class	1			2			5		
# of quadrats	6			6			6		
Species	Presence	2021	2023	Presence	2021	2023	Presence	2021	2023
hybrid white spruce							17%	0.2	1.7
lodgepole pine				17%	0.2	10.0	17%	0.2	2.5
subalpine fir					0.0	0.0	17%	0.2	1.0
Trees				17%	0.2	10.0	17%	0.2	5.2
Scouler's willow	17%	2.2	2.0	50%	1.3	0.8	66%	4.3	3.7
soopolallie					0.0	0.0			
alder				33%	5.0	4.7			
black huckleberry	83%	27.5	37.5	100%	36.8	43.3	83%	10.5	23.8
black twinberry	17%	1.5	1.3	17%	0.3	0.2			
birch-leaved spirea	50%	4.8	4.8	33%	0.4	0.4			
raspberry				17%	0.8	0.7	33%	1.3	1.0
Total Shrub Cover		35.3	45.7		43.3	70.1		15.3	28.5
fireweed	50%	5.3	4.8	33%	0.7	0.3	83%	13.3	14.2
heart-leaved arnica				33%	0.6	0.3	50%	3.8	3.3
single delight				17%	0.2	0.7			
pink wintergreen							33%	1.5	1.2
dwarf rattlesnake plantain				17%	0.2	0.3			
dandelion							17%	0.3	0.2
northern bedstraw							17%	2.7	2.5
Five-leaved bramble							66%	3.5	3.7
foamflower							17%	0.8	0.7
bunchberry	83%	15.5	18.0				83%	15.2	18.5
twinflower	33%	2.5	3.8	17%	0.3	0.2	66%	9.0	8.3
Total Herb Cover	1.0	22.7	26.7		1.4	1.8		46.8	52.5
bluejoint wheatgrass	17%	1.0	0.8	33%	0.4	0.1			
red-stemmed feathermoss				50%	3.7	3.2	50%	8.3	7.8
knight's plume				17%	7.7	7.5	66%	4.3	12.0
stiff club moss							17%	0.8	0.7
subalpine fir seedlings							66%	4.7	4.0
spruce seedlings	33%	7.5	7.2				66%	2.7	2.0

Mean vegetation covers by Age Class for transects on mesic, low burn severity sites, 2021 and 2023.

BEC	SBSmc2 and SBSdw3					
Site and soil	Circum-mesic, well to moderately- well drained loamy and coarse loamy soils on morainal blankets					
Age	Young (0-13 yr.) Stands			Age Class 4 and 5		
# of quadrats surveyed	42			12		
Year	Presence	2021	2023	Presence	2021	2023
lodgepole pine	2%	0.5	1.2			
Scouler’s willow	17%	0.6	2.9	33%	3.8	2.5
soopolallie	2%	0.0	0.3	8%	2.5	4.2
highbush cranberry	2%	0.0	0.4			
prickly rose				33%	2.5	1.3
alder	12%	3.0	7.4			
black huckleberry	71%	8.7	13.4	25%	0.4	0.9
birch-leaved spirea	26%	4.7	6.9	50%	3.5	1.8
Currant sp	10%	0.6	0.7			
raspberry	17%	0.9	0.5			
thimbleberry	12%	2.7	0.7			
kinnikinnick	10%	0.6	0.0	17%	0.3	0.5
dwarf blueberry	10%	2.9	3.0	67%	7.5	5.6
Total Shrub Cover		24.6	36.1		20.0	16.8
strawberry				8%	0.2	0.1
fireweed	81%	16.0	6.1	83%	11.6	2.1
willowherb	2%	0.0	0.3	17%	0.2	0.0
false Salomon's seal	2%	0.1	0.1			
cut-leaf anemone				8%	0.1	0.3
heart-leaved arnica	17%	4.0	1.3	8%	0.1	0.3
pink wintergreen	2%	0.0	0.1			
yarrow				17%	0.8	0.2
narrow leaved yellow hawkweed	5%	0.1	0.0	8%	0.1	0.2
dandelion	0%	0.0	0.1	8%	0.0	0.1
bunchberry	43%	5.3	5.6	58%	4.4	2.4
twinflower	10%	0.8	1.8	25%	0.3	1.0
Total Herb Cover	88%	26.3	15.5	100%	17.7	6.5
Ross's sedge	33%	2.4	2.0	33%	1.4	0.5
bronze sedge	7%	0.4	0.6			
bluejoint wheatgrass	26%	1.4	1.3	25%	2.1	1.1
short-awned ricegrass				33%	1.2	1.6
rough hairgrass	2%	1.2	0.4			
juniper haircap moss				25%	3.1	0.0
red-stemmed feathermoss	2%	0.6	0.0	8%	0.4	0.0
pine seedling	12%	0.1	0.3	58%	5.1	8.8
subalpine fir seedling				8%	0.1	0.1
spruce seedling	2%	0.1	0.2	8%	0.1	0.1
fire moss	21%	8.1	21.1	56%	0.0	18.1

Mean vegetation covers by Age Class for transects on mesic, high burn severity sites, 2021 and 2023.

BEC	SBSmc2								
Site and soil	Circum-mesic, well to moderately- well drained loamy and coarse loamy soils on morainal blankets								
Age	Young (0-13 yr.) Stands			Age Class 2			Age Class 5		
# of quadrats surveyed	24			18			6		
Year	P	2021	2023	P	2021	2023	P	2021	2023
trembling aspen	8%	0.5	1.5	6%	0.0	0.1			
Scouler's willow	38%	2.5	2.7	22%	1.9	7.1	83%	6.5	11.7
prickly rose	17%	1.4	0.5						
alder	13%	1.8	1.9	11%	2.2	1.9			
black huckleberry	33%	0.5	1.1	78%	6.1	9.2	83%	3.2	0.8
birch-leaved spirea	54%	8.2	11.4	50%	4.9	7.6	17%	2.5	0.3
raspberry	21%	0.8	1.2	0%	0.0	0.1	17%	0.0	0.3
trailing raspberry	8%	0.1	0.0				0%	0.0	0.0
thimbleberry	4%	0.1	0.2	6%	0.0	0.6	0%	0.0	0.0
dwarf blueberry	21%	1.7	5.3				0%	0.0	0.0
Total Shrub Cover		16.8	24.3		15.2	26.5		12.2	13.1
strawberry	8%	0.1	0.3				0%	0.0	0.0
fireweed	79%	15.1	2.0	83%	19.2	10.5	100%	29.7	11.6
heart-leaved arnica	17%	0.2	1.6	33%	0.8	0.5	33%	3.2	0.0
pink wintergreen							17%	0.0	0.1
showy aster	17%	1.7	0.7	6%	0.0	0.1			
narrow leaved yellow hawkweed	17%	0.5	0.4	28%	0.0	0.4			
white hawkweed	4%	0.0	0.2	28%	0.0	0.2			
dandelion	4%	0.1	0.2	6%	0.1	0.0			
northern bedstraw	4%	0.0	0.1						
bunchberry	17%	0.2	0.1						
twinflower	4%	0.0	0.0	22%	2.9	5.0			
showy pussytoes				6%	0.0	0.9			
viola species	4%	0.0	0.1						
Total Herb Cover		17.9	5.6		22.9	17.6		32.8	11.7
Ross's sedge	54%	4.3	3.0	72%	5.7	3.1	50%	10.0	10.8
bronze sedge	13%	1.1	0.5	6%	0.3	0.2			
bluejoint wheatgrass	33%	2.9	1.5	39%	2.9	4.8	17%	0.0	0.1
rough hairgrass	4%	tr	tr	6%	0.0	0.2			
bluegrass species	8%	0.5	0.0						
juniper haircap moss									
lodgepole pine seedling	8%	0.0	0.1	39%	0.2	2.2	17%	0.0	0.2
fire moss species	50%	32.2	14.5	94%	41.5	39.9	67%	28.8	52.5

Mean vegetation covers for Age Class 5 transect on dry, high burn severity sites, 2021 and 2023.

Species	# of quadrats present in 2021	Average % cover per plot 2021	# of quadrats present in 2023	Average % cover per plot 2023
Trembling aspen	2	27.5		32.5
Saskatoon	2	22.5	4	22.0
Birch-leaved spirea	5	7.9	5	10.0
Prickly rose	8	5.1	8	12.0
Soopolallie	1	4.0	1	15.0
Dwarf blueberry	9	1.5	7	3.4
Kinnikinnick	2	0.4	2	3.5
Bunchberry	5	2.6	2	0.8
Fireweed	7	6.0	6	1.1
Heart-leaved arnica	2	0.5	1	1.0
Showy Jacob’s ladder	1	5.0	0	0.0
Spike-like goldenrod	0	0.0	1	1.0
Ross’s sedge	9	13.2	8	4.9
Bluejoint	1	0.5	0	0.0
Rough-leaved ricegrass	0	0.0	2	6.0
Short-awned ricegrass	5	3.2	6	8.2

Appendix D. Stand Management Prescription

A. TENURE IDENTIFICATION

LICENCE NO.: A75068	CUTTING PERMIT: 107	BLOCK NO: BARA03	LICENSEE NAME: **Error! Reference source not found.**Nadleh Whut'en
	OPENING NUMBER (or map sheet): (*if available*) 500024553		LOCATION: Stuart – Nechako NRD, Sutherland FSR, km7, spur rd to east

B. AREA SUMMARY

AREA TO BE SPACED (ha)		
SU	SU AREA DESCRIPTION	NET AREA TO BE SPACED:
A	11-year-old pine and spruce plantation	**3**
	TOTAL AREA TO BE SPACED:	**3**

C. OBJECTIVES

C.1 MANAGEMENT OBJECTIVES

MANAGEMENT OBJECTIVES STATED IN THE FDP OR HLP(s):

In support of delivery of the Shovel Fire Ecosystem Restoration Plan, 3 hectares within 500024553 to be enhanced for black huckleberry production by removal of competing vegetation. Nadleh Whut'en use this site for harvesting of huckleberries, as it is within easy access of Nadleh as well Ormand Lake and is important for Culture Camp. Stand density is in excess of 6800 sph young 12 yr old lodgepole pine in portions of the stand at present, and huckleberry bushes are slowly being outcompeted for sunlight by lodgepole pine and Sitka alder. Roughly 1/3 of the stand has been affected by low severity fire. Spacing to 1200 sph and removal of some of the competing Sitka alder would enhance the site for huckleberry production. Target inter-tree distance = Sq rt (11,547/12,000) = 3 m. Void area resulting from wildfire damage will be left as natural openings. Hybrid white spruce occur is at low cover and will be left as is.

At this point this is a planned one-time treatment. Depending on success, further treatments may be planned in the future, or the site may be left to continue on its trajectory after the treatment has been completed.

C.2 CONDITIONS THAT MUST EXIST AFTER HARVEST OR TREATMENT TO ACCOMMODATE FOREST RESOURCES

C.2a WILDLIFE

Forage opportunities for wildlife will be enhanced through encouraging a more developed understory.

C.2b SENSITIVE AREAS

N/A

C.2c FISHERIES

N/A

C.2d WATERSHEDS

N/A

C.2e RECREATION

N/A

C.2f BIOLOGICAL DIVERSITY

Will be enhanced by encouragement of understory species for longer time periods.

C.2g VISUALS

N/A

C.2h CULTURAL HERITAGE

Partial removal of lodgepole pine and Sitka alder in order to enhance the site for huckleberry production. Nadleh Whut'en able to continue use of this site for harvesting of huckleberries, while other harvesting sites within their territory recover from the 2018 Shovel Lake Wildfire.

C.2i RANGE

N/A

C.2j OTHER RESOURCES

N/A

D. ECOLOGICAL INFORMATION

D.1 ECOLOGY							
	BIOGEOCLIMATIC						
SU	STRATUM	ZONE	SUBZONE	VARIANT	PHASE	SITE SERIES	PHASE
A		SBS	dw	3		01/03	

E. MANAGEMENT PRACTICES

E.1 RIPARIAN MANAGEMENT STRATEGIES

RIPARIAN RESERVE ZONE: N/A

RIPARIAN MANAGEMENT ZONE: N/A

E.2 FOREST HEALTH MANAGEMENT

MEASURES TO REDUCE FOREST HEALTH RISKS

The FFT Spacing Standard will be followed. i.e., when evaluating leave trees (Crop Trees) for good form and vigor the selected trees must optimize as many of the following characteristics as possible: (a) free of unacceptable insect damage, injury or disease; (b) healthy live crown of good colour; (c) straight stem with no forks or multiple tops; (d) a sturdy stem in relation to height, suited to resisting potential wind and snow damage after spacing; (e) small branch diameters; and (f) good terminal leader growth.

E.4 COARSE WOODY DEBRIS

MEASURES TO ACCOMMODATE CWD OBJECTIVES, INCLUDING VOLUME AND RANGE OF PIECE SIZES, IF ANY

Pine to be cut are less than 13 years old, and therefor considered “slash” and too small to meet definition of CWD. Slash to be left on site.

E.5 ARCHAEOLOGICAL SITES: N/A

F. STOCKING REQUIREMENTS

F.1 Stocking requirements and assessment dates from the original Site Plan will be maintained.

G. ADMINISTRATION

PRESCRIPTION PREPARED BY (RPF SIGNATURE AND SEAL):

John DeGagne

RPF Name (Printed)

Date: ____________________ RPF No: __________________

RPF Signature and Seal

Appendix E. Black Huckleberry Restoration Trial

The purpose of the trial is to test the feasibility of planting black huckleberry plugs on reclaimed land within the Coastal GasLink right-of-way. CGL intends to restore black huckleberry on site in 2025. While there is growing interest in planting native shrubs as part of reclamation plans, there is very little information available on the efficacy of planting black huckleberry on disturbed lands such as pipeline corridors. The seedlings provided by Woodmere nursery were inoculated with mycorrhizal fungi – the trial will test for survival and growth of plants on disturbed soils.

A local propagation and field trial conducted in Prince George by the Natural Resources and Environmental Studies Institute (NRESI) had limited survival of black huckleberry seedlings onto disturbed lands at the UNBC campus (2009). The authors advise that "without soil amendments and careful monitoring of moisture stress, it can be quite difficult to establish this species in areas dominated by bare mineral soil or subsoil, such as pipeline excavations, roadsides, or decommissioned roads and landings."

Site Attributes

The black huckleberry restoration trial was initiated in September 2023 at Nadleh First Nation's local berry patch that intersects with the Coastal Gas Link right of way at km 7.5 Sutherland FSR, north of Nadleh village. The site is located within the SBSdw3, on a gently sloping north aspect, at roughly 830 m elevation. The site intersects a young pine plantation with abundant huckleberry in the understory. During CGL's pipeline construction phase, trees were removed and shrub cover was mowed to roughly 10-15 cm height; the topsoil (20 to 30 cm) and vegetation layers were removed and stored to one side of the right-of-way. The top soil was reclaimed onto the site in August 2023. Site inspection prior to planting indicated that the loamy soil was very dry and had a loose non-aggregated soil structure, rocky but not compacted. The condition of soil mycorrhizae is unknown.

The Trial

Woodmere Nursery provided 50 black huckleberry plugs and 10 alder seedlings to Nadleh First Nation for the reclamation trial.

The planting trial was carried out as follows:

1. 5 plugs planted individually in reclaimed soil layer only;
2. 5 plugs planted individually in reclaimed soil layer only, and watered;
3. 5 plugs planted individually in reclaimed soil layer mixed with 1 L of humus-soil-inoculant-mix from an unburned huckleberry patch in the region, and watered;
4. 5 plugs planted individually in 1 L of 1 L of humus-soil-inoculant-mix plus 2 fertilizer "tea bags"; and, and watered;
5. Repeat of treatments 1 to 4, companion-planted with alder seedlings for shade and nitrogen fixing; and,
6. As a supplementary trial, participants transplanted a few clumps of huckleberry shrubs from the adjacent forest stand.

Moisture stress from drought conditions was addressed by implementing a watering protocol. Watering occurred at the time of planting, and will be continued at regular intervals during 2023 and 2024 as required.

There is potential for Nadleh First Nation to partner with Woodmere nursery in the larger huckleberry restoration project planned by Coastal GasLink for 2025.

Guidelines for Planting Black Huckleberry Plugs

Microsite selection and preparation

Seedlings require four basic elements to thrive: water, nutrients, sunlight, and room to grow. Grasses, weeds, and brush growing on the planting site threaten your new seedlings by competing for these basic requirements. 1. Don't plant seedlings near water holes, stumps, or rocks; and, 2. Avoid areas where soil appears compacted.

Planting technique

1. Create a small hole the depth of the seedling plug.
2. Plant the seedlings at the proper depth. The top of the soil plug should be 1 to 2 cm below ground level. If seedlings are planted too deep, their roots may not get enough oxygen. If they are planted too shallow, some roots may dry out.
3. Pack the soil well, but don't over pack it or slam the hole shut. Press gently but firmly to prevent shocking the roots. If air pockets remain around the roots due to poorly firmed soil, roots may dry out and die. Pack the soil firmly enough around the roots so a vigorous pull is required to loosen the seedling. If tea bag fertilizers are used, place so that they are not in direct contact with roots.
4. Water the soil well. Saturating the soil will reduce transplant stress due to low moisture.
5. Mulch to reduce moisture loss and competition, but leave space around the stem for oxygen.

Reference

McKechnie, I.M., Burton, P.J., Massicotte, H.B. 2009. Propagation and fungal inoculation of black huckleberry and velvet-leaved blueberry: How can these species be used in ecological reclamation? Natural Resources and Environmental Studies Institute Research Extension Note No 5, University of Northern British Columbia, Prince George, B.C., Canada.

Images from Sept 19, 2023. Brittani Sterling, Katailee Kilpatrick, and Serina Greene.